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A MINE SEWAGE-DISPOSAL STUDY

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

A MINE SEWAGE-DISPOSAL STUDY[1]

By R. T. Artz[2]

CONTENTS

	Page
Introduction	1
Acknowledgment	2
Underground method of sewage disposal	2
Portable receptacles	2
Septic tanks	2
Gases produced in septic tanks	3
Explosion hazard	3
Health hazards	4
A mine toilet system	6
Brief description of mine	7
Toilet facilities underground	7
Sewage-disposal system	7
Precautions for installation and operation of septic tanks in mines	8

INTRODUCTION

Disposal of sewage is an important part of mine sanitation. Improper handling and disposing of sewage are conducive to the spread of disease and often add foul and nauseating odors to the mine air. The diseases spread by unsafe methods of disposing of waste in mines are typhoid fever, cholera, amebic dysentery, hookworm, and other intestinal diseases due to parasites.[3]

Sanitary toilet facilities, with a good sewage-disposal system, each maintained in good order at all times, should help to prevent the spread of diseases transmitted by intestinal body wastes.

The metal- and nonmetal-mining industries have recognized the importance and need for disposing sewage properly; accordingly, facilities of some sort are installed and used today in most large mines. The coal-mining industry has given little thought to the disposal of sewage underground; however, in most mines of the anthracite industry, the inflow of large volumes of highly acid mine water and the extensive drainage system required to remove this water provide a natural means for disposing of sewage.

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[1] The Bureau of Mines will welcome the reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7392."

[2] Coal-mine inspector, Health and Safety Branch, Bureau of Mines, Pittsburgh, Pa.

[3] Sayers, R. R., Sanitation in Mines: Bureau of Mines, Miners Circ. 28, 1924, p. 6.

This publication contains general information concerning the disposal of sewage and describes the method of sewage disposal used in a limestone mine.

ACKNOWLEDGMENT

The author is indebted to the mine officials of the Columbia Chemical Division of the Pittsburgh Plate Glass Co., Barberton, Ohio, for supplying the information and drawings of the sewage-disposal system installed in their mine. Especial acknowledgment is due F. W. McKinnon, who designed the system and furnished much of the detailed information.

UNDERGROUND METHODS OF SEWAGE DISPOSAL

Two general methods are available for disposing of sewage from toilets placed in a mine: (1) The sewage can be collected in portable receptacles and transported to the surface for disposal, or (2) a septic tank can be provided underground. Usually, the latter method is not practicable because of physical conditions in the mine. It is conceivable that a combination of the two methods might be used advantageously in large mines; the septic tank could be centrally located underground and the portable receptacles transported to it for disposal of their contents.

Portable Receptacles

The portable receptacles for feces should be so designed and constructed that spreading of disease germs by flies, mice, rats, and water will be prevented. Watertight cans, 16 inches high and 16 inches in diameter, made of 18-gage galvanized iron and reinforced at the top and bottom with 2-inch iron bands, are satisfactory when suitable precautions are taken.

A close-fitting wooden box is necessary for holding the can at the toilet to prevent access of flies and mice, rats, or other small animals. It is desirable to provide a self-falling hinged lid for the seat.

A specially designed toilet car is used at some mines instead of the usual permanent toilet and portable can. The toilet car is similar to the rural type of privy, and the volume of the vault is limited by the volume beneath the seat. The unit is usually constructed of 3/16-inch steel plate, and care is taken to eliminate sharp corners and projections. Disinfectants are added periodically to the contents of the vault. When the vault is filled, the car is taken to the surface, and the vault is emptied and thoroughly cleaned before returning the unit to the mine.

Septic Tanks

The septic tank was first introduced about 1895 and was believed to be a panacea for the troubles of sewage disposal, but experience has proved that this was an optimistic expectation. It can, however, be made effective for domestic sewage. The process involves the reduction of the organic solids of the sewage to the form of liquid or gas by the action of bacteria.

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The bacterial action in a new tank usually does not start for 2 or 3 weeks; this is especially true for tanks coated with coal tars or creosotes, and they should not be condemned if the initial action is slow. However, some constituents of sewage may act as a bactericide, and the solids will not be reduced. Disinfectants, such as carbolic acid, corrosive sublimate, formaldehyde, and varieties of household antiseptics will prevent or destroy bacterial action.

The shape of the septic tank is unimportant, although there are some approximate dimensions that should be followed. The sewage should enter and the effluent should leave at about the mid-depth so as not to disturb the scum and sludge where the bacterial action takes place. Anything that hinders bacterial action will reduce the effectiveness of the tank.

The Imhoff tank, a refinement of the ordinary septic tank, is best-suited for the treatment of sewage. Sewage that is not readily acted upon by bacteria can be treated better in an Imhoff tank than in an ordinary septic tank. Special tanks and special methods are required for treating industrial wastes.

Unsatisfactory operation of a septic tank may be due to neglect or the presence of a bactericide or antiseptic, or the tank may be too large or too small for the amount of sewage to be treated. Most trade wastes act as bactericides, and chloride of lime should not be added to the sewage before it enters the tank or be poured into the tank. Deoderants may be trouble-makers if introduced into the tank.

GASES PRODUCED IN SEPTIC TANKS

The gases produced in the tank by the bacterial action are combustible, and they resemble natural gas because of tho high methane content; explosion and health hazards are involved in handling and disposing of them.[4]

Sewage gases ordinarily consist of carbon dioxide, oxygen, hydrogen sulfide, hydrogen, methane, and nitrogen. A tabulation of the composition of gases from sewage sludge digestion tanks[5] shows that carbon dioxide may range from 3.3 to 29.4 percent; oxygen, from 0.0 to 1.2 percent; hydrogen sulfide, from 0.0 to 0.1 percent; hydrogen, from 0.0 to 8.2 percent; methane, from 63.0 to 84.2 percent; and nitrogen, from 2.9 to 23.3 percent. Under certain conditions, some of these gases are toxic, and some are explosive when mixed with air in certain proportions.

Explosion Hazard

The explosion hazard arises from the presence of methane and hydrogen in the sewage gases. Hydrogen sulfide forms an explosive mixture when mixed with certain proportions of air, but the amounts of that gas present are so small that it may be disregarded as an explosion hazard.

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[4] Federation of Sewage Works Association, Occupational Hazards in the Operation of Sewage Works: Manual of Practice No. 1, 1944.

[5] Jones, G. W., Explosion and Health Hazards in Sewage Works Operation: Sewage Works Jour., vol. 5, No. 2, March 1933, p. 291.

Methane will explode if it is ignited when mixed with certain proportions of normal air, and the same is true for hydrogen. A mixture of normal air and 5 to 15 percent methane is explosive, and a mixture containing 4 to 74 percent hydrogen also is explosive.

Since sewage gases are usually deficient in oxygen, the explosion hazard will probably be nonexistent in the septic tank while it is in operation The danger is in the method of diluting these gases and dissipating them in the atmosphere, and in the tank itself when opened for inspection and cleaning.[6] The danger of an explosion can be minimized by observing the following precautions in connection with the installation and operation of septic tanks:

1. Keep sources of ignition away from the surroundings. Flames, sparks, or heated materials are sources of ignition. Flames from open lights, burning matches, cigar or cigarette lighters, and fires, or sparks from tools, lightning, and electric short circuits, or heated materials, such as glowing metals, hot cinders, and glowing tobacco, should not be permitted near the tank or its appurtenances.

2. Equip the tanks with a vent pipe to conduct the sewage gases and discharge them at some place of safety where dilution with air will be very rapid. Where septic tanks are installed and operated in a mine, the pipe should discharge into the main return airway; warning signs should be placed denoting the presence of the pipe.

3. Inspect and clean septic tanks. All possible sources of ignition should be kept away from the tank until it has been purged and thoroughly ventilated. This precaution is also necessary as a safeguard against the health hazard.

Health Hazards

The presence of hydrogen sulfide, high concentrations of carbon dioxide, and a deficiency of oxygen in the sewage gases may be detrimental to health. These gases are toxic or suffocating.

Hydrogen sulfide is exceedingly toxic, comparable to hydrogen cyanide, and in low concentrations it has a repulsive odor that may serve as a warning. Acute poisoning by hydrogen sulfide produces asphyxiation; and subacute poisoning produces irritation, such as conjunctivitis, bronchitis, pharyngitis, and depression of the central nervous system. Death from asphyxia is caused by paralysis of the respiratory center, while death from subacute poisoning is associated with edema of the lungs. The physiological response attending exposure to various concentrations of hydrogen sulfide in air is as follows:[7]

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[6] Jones, G. W., work cited in footnote 5, p. 300.

[7] Forbes, J. J., and Grove, G. W., Mine Gases and Methods for Their Detection: Bureau of Mines Miners' Circ. 33, 1938, p. 11.

0.005 to 0.010 percent:	Subacute poisoning - slight symptoms, such as mild conjunctivitis and respiratory tract irritation after 1 hour exposure.
0.02 to 0.03 percent:	Subacute poisoning - marked conjunctivitis and respiratory tract irritation after 1 hour exposure.
0.05 to 0.07 percent:	Subacute poisoning - dangerous in ½ to 1 hour exposure.
0.07 to 0.10 percent:	Possibly acute poisoning - rapid unconsciousness, cessation of respiration, and death.
0.10 to 0.20 percent:	Acute poisoning - rapid unconsciousness, cessation of respiration, and death in a few minutes.

Exposure to concentrations as low as 0.01 percent for long periods may be fatal. The exact low limit of concentration at which hydrogen sulfide ceases to act as a poison has not been determined, but it is evidently less than 0.005 percent[8] since subacute poisoning may be produced by long exposures to such a concentration.[9] In low concentrations hydrogen sulfide produces headache, sleeplessness, dullness, dizziness, and weariness. Pain in the eyes, followed by conjunctivitis, is fairly constant, while bronchitis and pains in the chest are frequent. Further poisoning produces depression, stupor, unconsciousness, and death. The heart continues to beat after respiration has ceased.

Carbon dioxide is a colorless and odorless gas about one and one-half times as heavy as air. A person at rest can breathe air containing 2 percent carbon dioxide for several hours without ill effects. Three or four percent causes an oppressive feeling, producing shortness of breath or panting, especially if one is working. Five to six percent produces stronger panting, headache, and flushing of the face; and it is possible to do very little work at these concentrations. Seven to ten percent may be fatal, depending on the length of exposure and the activity of the subject. The sensations of a person exposed to high concentrations of carbon dioxide have been described as follows: There is a sensation of great weight on the head, pressure in the temples, ringing in the ears, pungency in the nose, giddiness, loss of muscular power, and a strong desire to sleep.

Although oxygen is not usually considered toxic or noxious, a variation in its concentration cannot be neglected because it supports life. People breathe most easily and work best when the air contains about 21 percent oxygen, the amount usually present in air. Yet they can live and work, though not so well, when there is less oxygen. It is impossible to set a definite value for the minimum oxygen concentration necessary to sustain life because the value necessarily depends upon the individual's general health and stamina and the amount of work he is doing, as well as other conditions.

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[8] Sayers, R. R., Gas Hazards in Sewers and Sewage-Treatment Plants: Public Health Reports, vol. 49, 1934, p. 145.

[9] Sayers, R. R., and others, Investigations of Toxic Gases from Mexican and Other High-Sulphur Petroleums and Products: Bureau of Mines Bull. 231, 1925, 108 pp.

Oxygen deficiency appears to be the chief cause of the fatalities to persons entering sewage tanks.[10] If about 17 percent of the air is oxygen, men at work will breathe a little faster and a little deeper, about the same as when they first go from sea level to a height of 5,000 feet. Men breathing air that has as little as 15 percent of oxygen usually become dizzy, notice a buzzing in the ears, have a rapid heartbeat, and often suffer from headache. Very few men are free from these symptoms when the oxygen falls to 10 percent. Under certain conditions men may be conscious with as little as 3½ percent oxygen in the air they are breathing. However, under other conditions men faint or become unconscious when the air contains 9 percent of oxygen or less. Although men do not usually lose consciousness until very much less than 13 percent of oxygen is present, no one should try to enter or remain in an atmosphere in which a flame safety lamp or candle will not burn unless he wears a self-contained oxygen breathing apparatus.[11] When air contains only about 7 percent oxygen, life is greatly endangered.

Sewage gases are exceedingly toxic because the hydrogen sulfide content may be 0.1 percent, the carbon dioxide content may be 29.4 percent, and the oxygen content may be less than 1.2 percent. No one should be permitted to enter such an atmosphere in a tank unless he is protected by an approved hose mask or an approved self-contained oxygen breathing apparatus; a canister gas mask should not be used. As an additional precaution, the tank should be purged and ventilated thoroughly before it is entered.

A MINE TOILET SYSTEM

To successfully dispose of sewage from a toilet system in a mine has been a difficult problem for companies interested in improving sanitary conditions in mines. Physical conditions in the mine largely determine the feasibility of installing a septic tank for sewage disposal.

To provide good health conditions in and around the mine is a major item in the welfare policy of the Columbia Chemical Division of the Pittsburgh Plate Glass Co. Sanitary drinking fountains are strategically placed on the surface and in the mine. The bathhouse contains the necessary equipment, such as toilets, showers, individual clothes lockers, and wash basins, which are maintained in a sanitary condition at all times. An outstanding feature of the general health program is the periodic clinical examination of each underground employee.

The sanitary toilet facilities and sewage-disposal system described hereinafter were installed in 1944 and the lay-out of the installation is shown on the accompanying figures:

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[10] Jones, G. W., work cited in footnote 5, p. 299.
[11] Sayers, R. R., work cited in footnote 3, p. 10.

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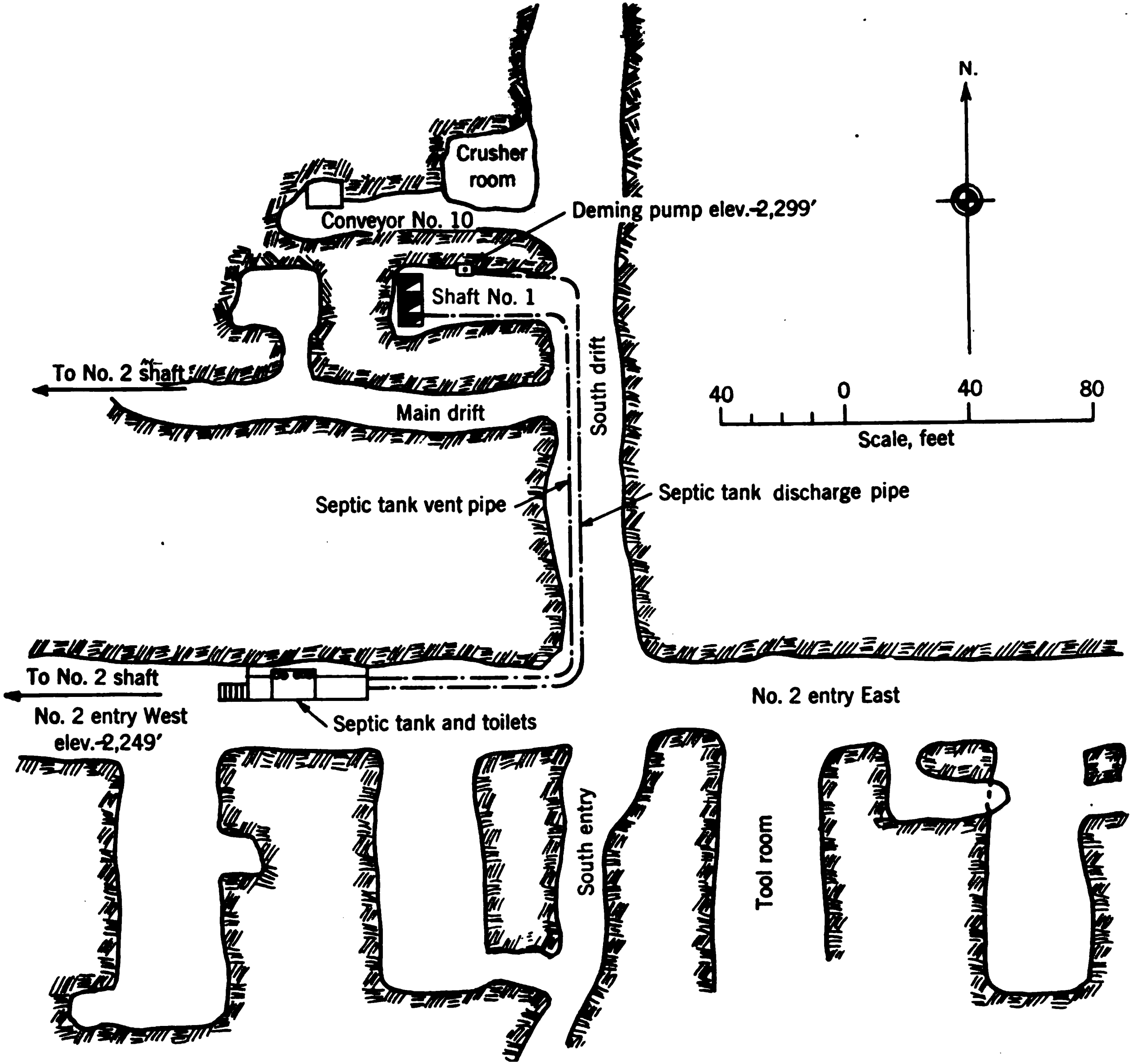

Figure I. - Location plan.

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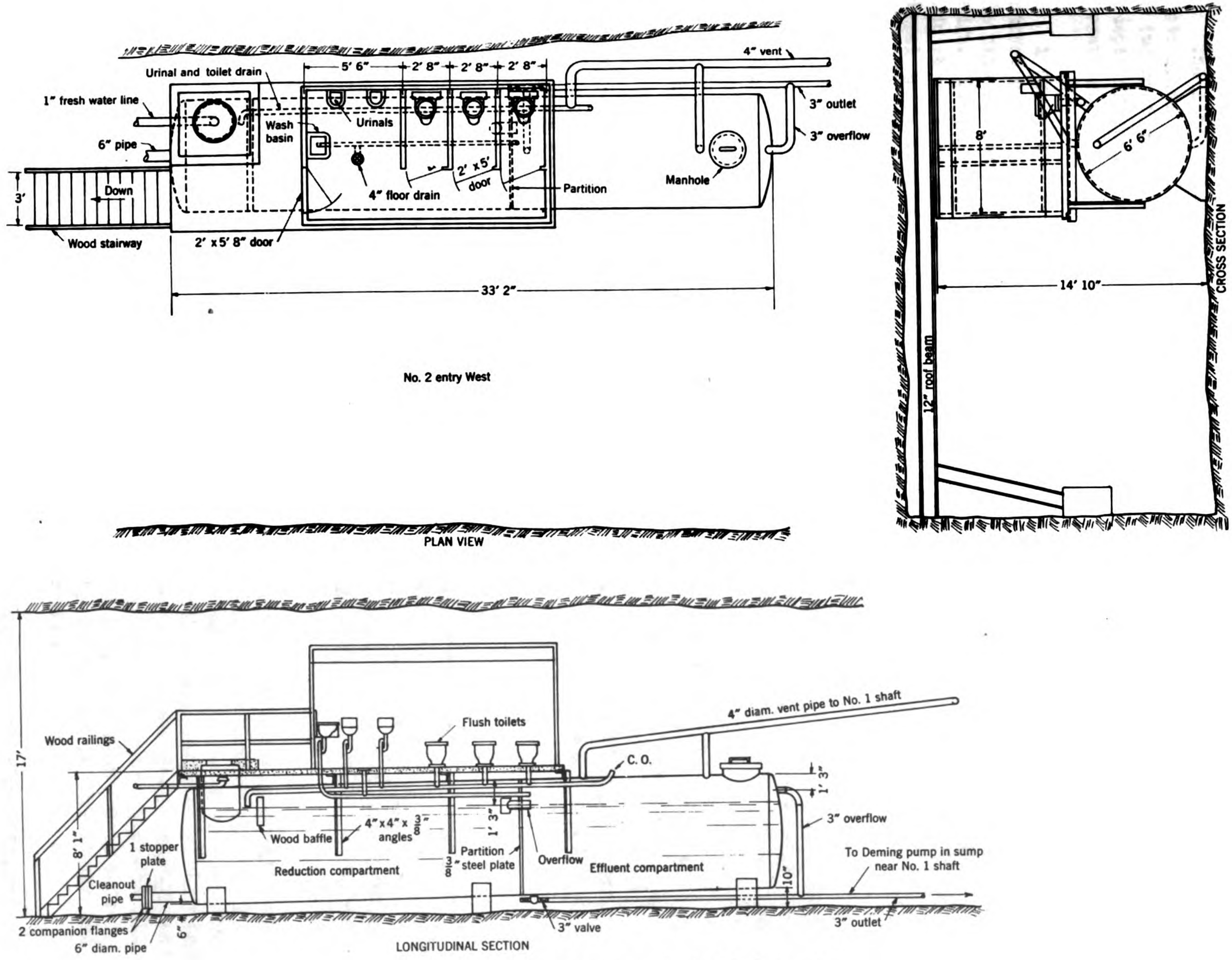

Figure 2. - Detail layout.

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Brief Description of Mine

The limestone mine of the Columbia Chemical Division of the Pittsburgh Plate Glass Co. is at Barberton, Summit County, Ohio. The mine is opened by two vertical shafts, which penetrate the Niagara limestone formation at a depth of approximately 2,200 feet and extend about 50 feet into the formation.

A two-entry room-and-pillar method of development and mining is used to extract a 28-foot horizontal bed of the formation at the 2,250-foot horizon. The mine operates 2 shifts daily, and about 60 men are employed on each shift. Drilling is done by jumbo-mounted drifter drills; loading, by electric shovels in the rooms and by scrapers in the entries; and haulage, by Diesel dump trucks.

Toilet Facilities Underground

The toilet facilities in the mine consist of a wash basin, two urinals, and three flush-type toilets. They are installed in a closure erected above the septic tank (fig. 2). The closure has a reinforced-concrete floor and wooden walls and partitions. Individual cubicles are provided for the flush toilets. A paper-towel dispenser, a soap dispenser, and a mirror are placed conveniently on the wall near the wash basin. A closed metal container is provided for the soiled towels. An attendant cleans the fixtures and the premises and disposes of the soiled towels daily. The supply of towels, soap, and toilet tissue is replenished as needed. The water for the wash basin and the flush boxes is secured from the pipe line which serves the refrigerated drinking fountain in the mine.

Sewage-Disposal System

The sewage-disposal system consists of a two-compartment, cylindrical septic tank and the necessary piping for carrying the influent and effluent. The tank is 33 feet 2 inches in length and 6 feet 6 inches in diameter; it is mounted on concrete cradles and slightly inclined to facilitate cleaning. A steel plate separates the reduction compartment from the effluent compartment.

An inclined collection pipe allows the sewage to flow by gravity from the toilets and urinals and discharges into the reduction compartment. A wooden baffle prevents the surging flow from disturbing the scum on the surface of the liquid. The organic solids in the sewage are reduced to liquids and gases by the action of bacteria. The liquids and gases pass through the overflow pipe from the reduction compartment into the effluent compartment. A tee placed on the end of the overflow pipe prevents the scum in the reduction tank from overflowing. A clean-out pipe is placed in the lower end of the reduction compartment to facilitate cleaning.

A 4-inch-diameter vent pipe is connected to the top of the effluent compartment and to the collection pipe. The gases released during the reduction process pass through this vent pipe and are discharged into the No. 1

shaft about 30 feet above the mine level. This shaft is the main return airway for the mine, and about 75,000 cubic feet of air a minute normally flows through it.

The overflow liquid accumulates in the effluent compartment. The discharge pipe of this compartment is connected to the suction pipe of the mine pump. When the level of the liquid reaches a predetermined height, the liquid is pumped to the surface and discharged into the surface sewage-disposal system.

PRECAUTIONS FOR INSTALLATION AND OPERATION OF SEPTIC TANKS IN MINES

The installation and operation of a septic tank in a mine may be ineffective or dangerous unless proper precautions are taken to reduce or prevent the existence of health and explosion hazards. The important precautions are:

1. The size of the septic tank must be adequate for the volume of sewage to be disposed, with consideration given to the composition of the sewage.

2. The sewage must enter and the effluent leave the reduction compartment of the tank in a manner that will not disturb the scum on the surface of the liquid.

3. Disinfectants, antiseptics, and deodorants should be used sparingly unless they are of a type that will not destroy or hinder the bacterial action.

4. A vent must be provided for removing the gases formed by the reduction process and for discharging them at some place of safety where dilution will be rapid.

5. The tank should be designed and constructed so as to prevent uncontrolled escape or removal of the gases and liquid. Water traps or seals should be suitably placed in all pipe lines connected to the tank, except the vent pipe.

6. Flames, sparks, heated materials, or other possible igniting agents should not be permitted at or near the tank or the vent-pipe discharge.

7. Persons should not enter a tank for any reason unless the tank has been purged and thoroughly ventilated, or unless they are protected by an approved hose mask or a self-contained oxygen breathing apparatus; canister-type gas masks should not be used.

8. The tank should be placed in a separate room or opening that is fireproofed and is ventilated by a separate split of air.